CHAPTER 1: HISTORY AND SCOPE OF REMOTE SENSING
“A picture is worth a thousand words.”
Each remote sensed image can truthfully be said to distill the meaning of at least a thousand words. Therefore, specialized knowledge is important because they have qualities that differ from those we encounter in everyday experience:

- **Image presentation**
- **Unfamiliar scales and resolutions**
- **Overhead views from aircraft or satellites**
- **Use of several regions of the electromagnetic spectrum**
SOME DEFINITIONS OF REMOTE SENSING
**TABLE 1.1. Remote Sensing: Some Definitions**

Remote sensing has been variously defined but basically it is the art or science of telling something about an object without touching it. (Fischer et al., 1976, p. 34)

Remote sensing is the acquisition of physical data of an object without touch or contact. (Lintz and Simonett, 1976, p. 1)

Imagery is acquired with a sensor other than (or in addition to) a conventional camera through which a scene is recorded, such as by electronic scanning, using radiations outside the normal visual range of the film and camera—microwave, radar, thermal, infrared, ultraviolet, as well as multispectral, special techniques are applied to process and interpret remote sensing imagery for the purpose of producing conventional maps, thematic maps, resources surveys, etc., in the fields of agriculture, archaeology, forestry, geography, geology, and others. (American Society of Photogrammetry)

Remote sensing is the observation of a target by a device separated from it by some distance. (Barrett and Curtis, 1976, p. 3)

The term "remote sensing" in its broadest sense merely means "reconnaissance at a distance." (Colwell, 1966, p. 71)

Remote sensing, though not precisely defined, includes all methods of obtaining pictures or other forms of electromagnetic records of the Earth’s surface from a distance, and the treatment and processing of the picture data. . . . Remote sensing then in the widest sense is concerned with detecting and recording electromagnetic radiation from the target areas in the field of view of the sensor instrument. This radiation may have originated directly from separate components of the target area; it may be solar energy reflected from them; or it may be reflections of energy transmitted to the target area from the sensor itself. (White, 1977, pp. 1–2)

“Remote sensing” is the term currently used by a number of scientists for the study of remote objects (earth, lunar, and planetary surfaces and atmospheres, stellar and galactic phenomena, etc.) from great distances. Broadly defined . . . , remote sensing denotes the joint effects of employing modern sensors, data-processing equipment, information theory and processing methodology, communications theory and devices, space and airborne vehicles, and large-systems theory and practice for the purposes of carrying out aerial or space surveys of the earth’s surface. (National Academy of Sciences, 1970, p. 1)

Remote sensing is the science of deriving information about an object from measurements made at a distance from the object, i.e., without actually coming in contact with it. The quantity most frequently measured in present-day remote sensing systems is the electromagnetic energy emanating from objects of interest, and although there are other possibilities (e.g., seismic waves, sonic waves, and gravitational force), our attention . . . is focused upon systems which measure electromagnetic energy. (D. A. Landgrebe, quoted in Swain and Davis, 1978, p. 1)
"It is the science of deriving information about an object without actually coming in contact with it."
“It is the practice of deriving information about the Earth’s land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the Earth Surface.”
<table>
<thead>
<tr>
<th>Year(s)</th>
<th>Event</th>
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<tbody>
<tr>
<td>1800</td>
<td>Discovery of infrared by Sir William Herschel</td>
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<td>1839</td>
<td>Beginning of practice of photography</td>
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<td>1847</td>
<td>Infrared spectrum shown by A. H. L. Fizeau and J. B. L. Foucault to share properties with visible light</td>
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<td>1850–1860</td>
<td>Photography from balloons</td>
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<tr>
<td>1873</td>
<td>Theory of electromagnetic energy developed by James Clerk Maxwell</td>
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<tr>
<td>1909</td>
<td>Photography from airplanes</td>
</tr>
<tr>
<td>1914–1918</td>
<td>World War I: aerial reconnaissance</td>
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<tr>
<td>1920–1930</td>
<td>Development and initial applications of aerial photography and photogrammetry</td>
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<tr>
<td>1929–1939</td>
<td>Economic depression generates environmental crises that lead to governmental applications of aerial photography</td>
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<tr>
<td>1930–1940</td>
<td>Development of radars in Germany, United States, and United Kingdom</td>
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<tr>
<td>1939–1945</td>
<td>World War II: applications of nonvisible portions of electromagnetic spectrum; training of persons in acquisition and interpretation of airphotos</td>
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<tr>
<td>1950–1960</td>
<td>Military research and development</td>
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<tr>
<td>1956</td>
<td>Colwell’s research on plant disease detection with infrared photography</td>
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<tr>
<td>1960–1970</td>
<td>First use of term <em>remote sensing</em></td>
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<td>TIROS weather satellite</td>
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<td>Skylab remote sensing observations from space</td>
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<td>1972</td>
<td>Launch of Landsat 1</td>
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<td>1970–1980</td>
<td>Rapid advances in digital image processing</td>
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<tr>
<td>1986</td>
<td>SPOT French Earth observation satellite</td>
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<td>1980s</td>
<td>Development of hyperspectral sensors</td>
</tr>
<tr>
<td>1990s</td>
<td>Global remote sensing systems, lidars</td>
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MILESTONE IN THE HISTORY OF REMOTE SENSING PLATFORMS

Balloons → Pigeons → Airplanes → Satellites
1859 - Gaspard Felix Tournachon (also known as Nadar) used balloons as platforms to take the first aerial photographs.

1880 - M. A. Batut took aerial photos in France using kites.
1903 – Bavarian Pigeons are used with the first light camera. This camera took photos every 30 seconds during the bird flight. They were faster than balloons and much smaller.

1908 - Wilbur Wright was a very important pilot for remote sensing. The first photograph from an airplane was taken by L. P. Bonvillain in France during a demo flight.
The planes replaced the balloons and pigeons in observing the enemy lines.

Aerial photography was strongly developed.

Photos were used by world nations for aerial reconnaissance.

At the end of the wars this new technology was very much appreciated.
The science of photogrammetry was applied to aerial photography.

**Photogrammetry** is the practice of making accurate measurements from photographs.
COLD WAR ERA: THE CUBAN MISSILE CRISIS (1962)

• In fall 1962, reports indicated that the soviets were installing nuclear missies in Cuba.

• Satellite and U-2 images proved the existence of such missiles.

• Both nations depended on images processing and interpretation (remote sensing) for evaluation and making decisions.
Remote sensing techniques helped to take pictures of the moon surface in order to make lunar maps.

Apollo 8 took the first photos of the Earth from space.

YouTube Video: NASA | Earthrise: The 45th Anniversary  
https://youtu.be/dE-vOscpiNc
First multispectral photos were taken in 1968 on board Apollo 9 mission.

Four Hasselblad cameras were installed in the same platform and looking toward the same direction in order to take pictures at the same time for the same object.

These multispectral pictures were digitized and used to develop image processing techniques that later were used with Landsat data.
In July 1972 NASA launched the first “Earth Resources Technology Satellite” (ERTS-1).

These multispectral data provided a better understanding of our planet, including land used and land cover, urban development, and Earth global processes.

The name was later changed to LANDSAT and it has been a very successful long-term mission.
In the 70’s other sensors were developed to acquire images in other regions of the electromagnetic spectrum besides the visible, like the mid infrared and the thermal infrared.

They had large field of view (in hundreds of kilometers).

Such large scale cover was valuable for meteorology.
• The Ozone Hole over the Antarctica, discovered by British scientists, was confirmed by the Nimbus-7 Total Ozone Mapping Spectrometer (TOMS) launched in 1978.

• Since then, different sensors have made daily maps of global ozone concentration.

• TOMS data were used as scientific evidence in the First Protocol of Montreal, were 40 nations agreed to reduce the use of CFC’s in 50% for year 1999.
EARTH OBSERVING SYSTEM
1990’s

Hyperspectral Remote Sensing

Global Remote Sensing
IN THE 2000’S
TOWARD A NEW CENTURY WITH HIGHER RESOLUTION

IKONOS
1 METER

HYPERION
220 BANDS
DigitalGlobe has established itself as the world’s most prominent supplier of high-resolution commercial satellite imagery. DigitalGlobe’s constellation of satellites is unprecedented in the commercial imaging industry, enabling commercial and government customers around the globe to access a broad selection of

WorldView-2, launched October 2009, is the first high-resolution 8-band multispectral commercial satellite. Operating at an altitude of 770 kilometers, WorldView-2 provides 46 cm* panchromatic resolution and 1.84 meter* multispectral resolution. WorldView-2 has an average revisit time of 1.1 days and is capable of collecting up to 975,000 square kilometers (376,000 square miles) per day**, more than tripling the DigitalGlobe multispectral collection capacity for more rapid and reliable collection.

The WorldView-2 system, offering incredible accuracy, agility, capacity and spectral diversity, allows DigitalGlobe to substantially expand its imagery product offerings to both commercial and government customers.
WorldView-3 Satellite Sensor

DigitalGlobe’s satellite WorldView-3 is an advanced fourth-generation satellite successfully launched on August 13, 2014 and will offer 0.31 meter resolution panchromatic band and 8 multi-spectral, 8 SWIR and 12 CAVIS bands.

WorldView-3 Satellite Sensor (0.31m)

The WorldView-3 satellite sensor was licensed by the National Oceanic and Atmospheric Administration (NOAA) to collect in addition to the standard Panchromatic and Multispectral bands, eight-band short-wave infrared (SWIR) and 12 CAVIS imagery. The satellite was successfully launched on August 13, 2014. Watch satellite launch.

WorldView-3 Satellite Sensor (0.31m)

(Image Copyright © DigitalGlobe)
OVERVIEW OF REMOTE SENSING PROCESS

PHYSICAL OBJECTS

SENSOR DATA

EXTRACTED INFORMATION

APPLICATIONS

LAND USE

HYDROLOGY

SOILS

GEOLOGY

VEGETATION
DETECTING THE REMOTE SIGNAL
ACQUISITION OF A REMOTE SENSED IMAGE
SPECTRAL DIFFERENTIATION - Remote sensing depends on observed spectral differences in the energy reflected or emitted from features of interest.

Spectral Resolution: This refers to the number of bands in the spectrum in which the instrument can take measurements.

- Human Eye = 3 channels (RGB) + 1 Pan.
- Landsat TM = 7 channels
- SeaWiFS = 8 channels
- AVIRIS = 224 channels.
RADIOMETRIC DIFFERENTIATION - Examination of any image acquired by remote sensing ultimately depends on detection of differences in the brightness of objects and the features.

Radiometric Resolution: This is the sensitivity to small differences in the radiation of an observed object.

- Landsat TM = 8 bits
- MODIS = 12 bits
- ERS SAR = 16 bits
SPATIAL DIFFERENTIATION - Every sensor is limited in respect to the size of the smallest area that can be separately recorded as an entity on an image.

Spatial Resolution: This represents the ability of the sensor to detect and distinguish small objects and fine detail in larger objects. Depends on the instrument's sensitivity and distance from the object, and defines the pixel size of a digital image.

- Landsat TM = 30 m
- AVHRR = 1 km
- Meteosat = 7 Km
- IKONOS = 1 m
KEY CONCEPTS OF REMOTE SENSING

TEMPORAL DIMENSIONS- Although a single image can easily demonstrate the value of remotely sensed imagery, its effectiveness is best demonstrated through the use of many images of the same region acquired over time.

TEMPORAL RESOLUTION:
Represents the frequency with which a sensor can revisit an area of interest and acquire a new image. Depends on the instrument's field of vision, and the platform (i.e. satellite vs. airplane).

SeaWiFS Images: Biosphere Animation
KEY CONCEPTS OF REMOTE SENSING

GEOMETRIC TRANSFORMATION - Every remotely sensed image represents a landscape in a specific geometric relationship determined by the design of the remote sensing instrument, specific operating conditions, terrain relief, and other factors.

Each image includes positional errors caused by the perspective of the sensor optics, the motion of scanning optics, terrain relief, and Earth curvature.
The image analyst must always be conscious of the fact that the many components of the remote sensing process act as a system and therefore cannot be isolated from one another. This means that the interpreter must know the remote sensing system and the subject of the interpretation.
ROLE OF THE ATMOSPHERE - All energy reaching the remote sensing instrument must pass through a portion of the Earth's atmosphere. The Sun's energy is altered in intensity and wavelength by particles and gases in the Earth's atmosphere.

These changes appear on the image in ways that degrade image quality or influence the accuracy of interpretation.

In satellite images the Atmosphere is 90% of the total signal.
IN SUMMARY...
THE KEY CONCEPTS OF REMOTE SENSING ARE:

1. Spectral Differentiation
2. Radiometric Differentiation
3. Spatial Differentiation
4. Temporal Dimension
5. Geometric Transformation
6. Remote Sensing Instrumentation
   Acts as a System
7. Role of the Atmosphere
1. SPECTRAL RESOLUTION: This refers to the number of bands in the spectrum in which the instrument can take measurements.
   
   **Landsat TM = 7 channels**

2. RADIOMETRIC RESOLUTION: This is the sensitivity to small differences in the radiation of an observed object.
   
   **Landsat TM = 8 bit**

3. SPATIAL RESOLUTION: This represents the ability of the sensor to detect and distinguish small objects and fine detail in larger objects. Depends on the instrument's sensitivity and distance from the object, and defines the pixel size of a digital image.
   
   **Landsat TM = 30m**

4. TEMPORAL RESOLUTION: Represents the frequency with which a satellite can re-visit an area of interest and acquire a new image. Depends on the instrument's field of vision, and the satellite's orbit.
   
   **Landsat TM 16 days**
1. Read Chapter 1 and answer the review questions 2, 4, and 8 (at the end of the chapter).

2. Read Chapter 2.